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(12) # EUROPEAN PATENT SPECIFICATION

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Description

The invention relates to a method of providing a layer on a substrate, whereby during a certain process time material is detached from a target plate through a bombardment of this target plate with ions from a gas discharge under reduced pressure in a reactor chamber which is provided with a support for the substrate, while measures are taken to achieve a better adhesion of material which is deposited on a surface of a chamber component near the support.

Such a method is particularly suitable for the manufacture of a semiconductor device, on which often metal layers are provided (sputtered), which are given a pattern and function as conductors after the semiconductor device has been finished. Because of an ever increasing packing density of semiconductor devices (VLSI circuits), high quality requirements are set for such metal layers.
During sputtering, it cannot be avoided that a portion of the sputtered material fails to reach the surface of the semiconductor slice and is deposited on a surface of a chamber component near the semiconductor slice, usually on a wall, screen, control electrode, or closure member. This material generally has a bad adhesion, so that there is a risk of this material becoming detached from the said surface in the form of particles which may contaminate the slice. Such particles can interfere with the metal layer, so that the semiconductor device manufactured by the method does not function correctly. In general, therefore, measures have to be taken to prevent such contamination of the semiconductor slice.

A method of the kind mentioned in the opening paragraph is known from the Japanese Patent Application no. 63-162861, whereby the surface of the chamber wall near the semiconductor slice is roughened in order to give material deposited there a better adhesion.

The known method described has the disadvantage that still too many particles reach the semiconductor substrate in practice. Another disadvantage is that the roughening of the chamber component leads to a surface area which is greater than in the case of a smooth chamber component. Such a greater surface area is capable of adsorbing and desorbing more impurities, so that the reduced pressure necessary for the sputtering process is less easy to achieve and maintain.

The invention has for its object *inter alia* to counteract the drawbacks mentioned.

The method according to the invention is for this purpose characterized in that the measure for giving the material a better adhesion consists in that the surface of the chamber component is bombarded with ions from the gas discharge for at least part of the process time.

It has been found that, if the chamber component near the support is bombarded with ions, material from the target plate ending up there has a very good adhesion. The adhesion turns out to be so good that no particles become detached from the chamber component. This is because the ions provide a strong adhesion owing to a so-called ion-plating process, whereby the ions penetrate the surface a few atom layers deep. The chamber component need not be roughened, so that no problem arises concerning achieving and maintaining the reduced pressure. In practice it is usually not necessary to bombard the surface of the chamber component with ions throughout the entire sputtering process. It suffices to bombard the surface of the chamber component with ions during some time after, for example, an interruption in the sputtering process, or after a temporary higher pressure in the reactor chamber, for example, during the exchange of the target plate. It is suspected that the surface becomes contaminated during such an interruption in the sputtering process, with the result that the material no longer adheres satisfactorily. A layer of material with good adhesion is fixed to the chamber component by the simultaneous bombardment with ions. This layer has a clean surface on which, also after the bombardment has stopped, material will have a good adhesion. The bombardment of the chamber component may take place without the semiconductor slice being present, provided that it is ensured that no contamination of the chamber component takes place after the bombardment.

Preferably, the method according to the invention is characterized in that the ion bombardment of the surface of the chamber component is achieved by giving this surface such a potential that the ions of the gas discharge are attracted. In this way it is very simple to send ions to the surface of the chamber component. The value of the potential is so taken that the ions penetrate the surface a few atom layers deep. A potential of 500 to 1000 V is usually sufficient for this.

Problems involving bad adhesion to the chamber component in the manufacture of semiconductor devices occur particularly when layers of tungsten or of a tungsten alloy are provided. The method accordingly is preferably characterized in that the material consists of tungsten or a tungsten alloy.

When the semiconductor slice is present and the surface of the chamber component is bombarded with ions, a portion of these ions may hit the semiconductor slice and cause radiation damage there. In addition, material may be sputtered off the chamber component and contaminate the semiconductor slice. Preferably, therefore, a substrate

present in the support is screened off during the bombardment of the chamber component.

The invention will be explained in more detail by way of example below, with reference to a drawing. In the drawing:

Fig. 1 shows a system for sputtering metal layers by the method according to the invention.

The Figure is purely diagrammatical and not drawn to scale.

Fig. 1 diagrammatically shows a device for providing a layer on a semiconductor substrate 1, comprising a reactor chamber 2 with means 3 for generating a gas discharge 4, a support 5 for a target plate 6, and a support 7 for the semiconductor substrate 1. The means 3 for generating the gas discharge 4 comprise, for example, a supply unit 3 which delivers the electric power required for the gas discharge 4. The target plate 6 acts as a first electrode and the semiconductor slice 1 as the second electrode for transferring the electric power of the supply unit 3. During a certain process time, material 8 is detached from the target plate in the reactor chamber 2 under reduced pressure by a bombardment of the target plate 6 with ions from the gas discharge 4, which material is then deposited on the semiconductor substrate 1. Such a device and such a method are particularly suitable for providing metal layers on semiconductor substrates, the metal layers acting as conductor patterns on semiconductor devices after etching and patterning. Part of the material 8, however, will also be deposited on components of the reactor chamber 2 near the semiconductor slice 1. Such a chamber component is, for example, a screen 9, which serves to prevent contamination of the reactor wall and sputtering-off of the rear of the holder 5 and the target plate 6, but it may also be formed by the wall 10 of the reactor chamber, by a closure member 11, by an auxiliary electrode (not shown), or some such item. It appears in practice that, for example after opening of the reactor chamber 2, material 8 reaching the surface of the screen 9 has bad adhesion and that this material can become detached from the surface of the screen 9 in the form of particles and can thus contaminate the semiconductor slice 1. It is suspected that during opening the surface of the screen 9 is contaminated, so that the material 8 has bad adhesion. According to the invention, means are present in the device for bombarding the surface of the screen 9 with ions from the gas discharge 4. When the surface of the screen 9 is bombarded with ions from the gas discharge 4 for at least part of the process time, it is achieved that the material 8 will have very good adhesion thereon. After the bombardment of the screen 9, the surface of the screen will be provided with a clean, well-adhering layer. When the sputtering process is continued, material reaching this layer will also have good adhesion thereon, so that the generation of particles which can become detached and can reach the semiconductor slice is prevented. It is not necessary for good adhesion of material of the target plate on chamber components near the support of the semiconductor slice that the semiconductor slice is present, provided of course that no new contamination of the surface of the chamber components takes place during loading of the semiconductor slice, which can be achieved, for example, in that the semiconductor slice 1 is introduced through a load lock (not drawn). The means for bombarding the surface of the chamber component comprise, according to the invention, an electric connection 12 for giving the surface of the chamber component such a potential that the ions from the gas discharge 4 are attracted. Thus ions from the gas discharge 4 can be attracted towards the surface of the chamber component in a simple manner.

When a chamber component near the support 7 of the semiconductor slice 1 is subjected to an ion bombardment, while a semiconductor slice is present in the support, a portion of these ions can hit the semiconductor slice and cause radiation damage there. According to the invention, therefore, the device has a closure member 11 in front of the support 7 of the semiconductor slice 1, with which the semiconductor slice can be screened off. Thus a semiconductor slice 1 present in the support 7 is screened during the bombardment of the chamber component 9. Radiation damage is prevented in this way.

In practice, the reactor chamber 2 is kept at a reduced pressure through an output 13 by means of a vacuum pump 14. Argon gas is introduced into the reactor chamber, which has a pressure of approximately $6.7 \cdot 10^{-7}$ hPa (5×10^{-7} torr), through an inlet 15. The supply unit 3 provides an electric field between the target plate 6, which acts as a first electrode, and the semiconductor slice 1 of approximately 15 cm diameter, which acts as the second electrode. The gas is induced to form a gas discharge 4 through interaction with the electric field. The target plate 6 comprises the material 8 from which the layer on the semiconductor slice 1 is formed. This material 8 may contain *inter alia* metals such as platinum, titanium, titaniumnitride, or aluminium, but alternatively tungsten or a tungsten alloy may also be used.

During the sputtering process, the reactor chamber is evacuated to a pressure of $6.7 \cdot 10^{-7}$ hPa (5×10^{-7} torr), after which argon gas is introduced to achieve a pressure of $6.7 \cdot 10^{-7}$ hPa (5×10^{-3} torr). The support 5 and the target plate 6 are given a potential of -500 V (power 5 kW) by the supply unit 3, while the support 7 and the semiconductor slice 1 are at ground potential. The argon

ions are attracted by the target plate 6 and will detach tungsten atoms 8 therefrom, which atoms are subsequently deposited on the semiconductor slice 1, but also partly on components of the reactor chamber near the semiconductor slice, such as the screen 9. After opening of the reactor chamber 2, for example, the tungsten will show bad adhesion to the screen 9. The badly adhering tungsten may become detached from the surface of the screen 9 in the form of particles and thus contaminate the semiconductor slice 1. According to the invention, therefore, the screen 9 is given a potential of -1000 V for a short period, for example approximately 1 minute, after a possible contamination of the surface of this screen, in order to attract argon ions from the gas discharge 4 towards the screen 9. The semiconductor slice 1 is preferably not present during this. The argon ions ensure a very good adhesion of the tungsten 8 to the screen 9, so that the generation of loose tungsten particles capable of contaminating the semiconductor slice 1 is prevented. After this, preliminary sputtering takes place for approximately 1 minute in that the target plate is set at -500 V (power 5 kW), during which the closure member 11 and the support 7 for the semiconductor slice 1 are at ground potential. Then the gas discharge is switched off and the semiconductor slice 1 is introduced into the reactor chamber through a so-called load lock without interruption of the vacuum and positioned on the support. The semiconductor slice 1 is screened off by the closure member 11 and preliminary sputtering takes place for 1 to 2 seconds. After preliminary sputtering, the closure member 11 is turned away, upon which a 100 nm thick tungsten layer is provided on the slice 1 during, for example, 1 minute. This tungsten layer may then be patterned by means of usual etching techniques, so that the layer can be used, for example, as a conductor layer in a semiconductor device.

A metal layer which is not contaminated by particles issuing from chamber components is obtained by the method described above.

The invention is described above for the provision of a layer on a semiconductor substrate. The invention is particularly suitable for this, but it is not limited to such substrates. The method is also useful when other substrates are to be provided with layers which must meet high quality requirements. Examples are the provision of metal layers on glass, such as during the manufacture of liquid crystal display television screens (LC-TV).

Claims

1. A method of reducing particle contamination during sputtering in a process of providing a layer on a substrate, whereby during a certain process time material is detached from a target plate through a bombardment of this target plate with ions from a gas discharge under reduced pressure in a reactor chamber which is provided with a support for the substrate, while measures are taken to achieve a better adhesion of material which is deposited on a surface of a chamber component near the support, characterized in that the measure for giving the material a better adhesion consists in that the surface of the chamber component is bombarded with ions from the gas discharge for at least part of the process time.

2. A method as claimed in Claim 1, characterized in that the ion bombardment of the surface of the chamber component is achieved by giving this surface such a potential that the ions of the gas discharge are attracted.

3. A method as claimed in any one of the preceding Claims, characterized in that the material consists of tungsten or a tungsten alloy.

4. A method as claimed in any one of the preceding Claims, characterized in that a substrate present in the support is screened off during the bombardment of the chamber component.

Patentansprüche

1. Verfahren zum Reduzieren von Teilchenverunreinigung beim Zerstäuben in einem Verfahren zum Anbringen einer Schicht auf einem Substrat, wobei in einer bestimmten Verfahrenszeit Material von einer Targetplatte durch einen Beschuß dieser Targetplatte mit Ionen aus einer Gasentladung unter reduziertem Druck in einer Reaktorkammer freigesetzt wird, die mit einem Träger für das Substrat versehen ist, während Maßmahmen zum Erhalten einer besseren Haftung von Material getroffen werden, das auf einer Oberfläche eines Kammerbauteils nahe dem Träger abgeschieden ist, dadurch gekennzeichnet, daß die Maßnahme für eine bessere Haftung des Materials darin besteht, daß die Oberfläche des Kammerbauteils mit Ionen aus der Gasentladung wenigstens für einen Teil der Verfahrenszeit beschossen wird.

2. Verfahren nach Anspruch 1, dadurch gekennzeichnet, daß der Ionenbeschuß der Oberfläche des Kammerbauteils dadurch erhalten wird, daß diese Oberfläche einem derartigen Potential zugeführt wird, daß die Ionen der Gasentladung angezogen werden.

3. Verfahren nach einem oder mehreren der vorangehenden Ansprüche, dadurch gekennzeichnet, daß das Material aus Wolfram oder aus einer Wolframlegierung besteht.

4. Verfahren nach einem oder mehreren der vorangehenden Ansprüche, dadurch gekennzeichnet, daß ein Substrat im Träger beim Beschuß des Kammerbauteils abgeschirmt wird.

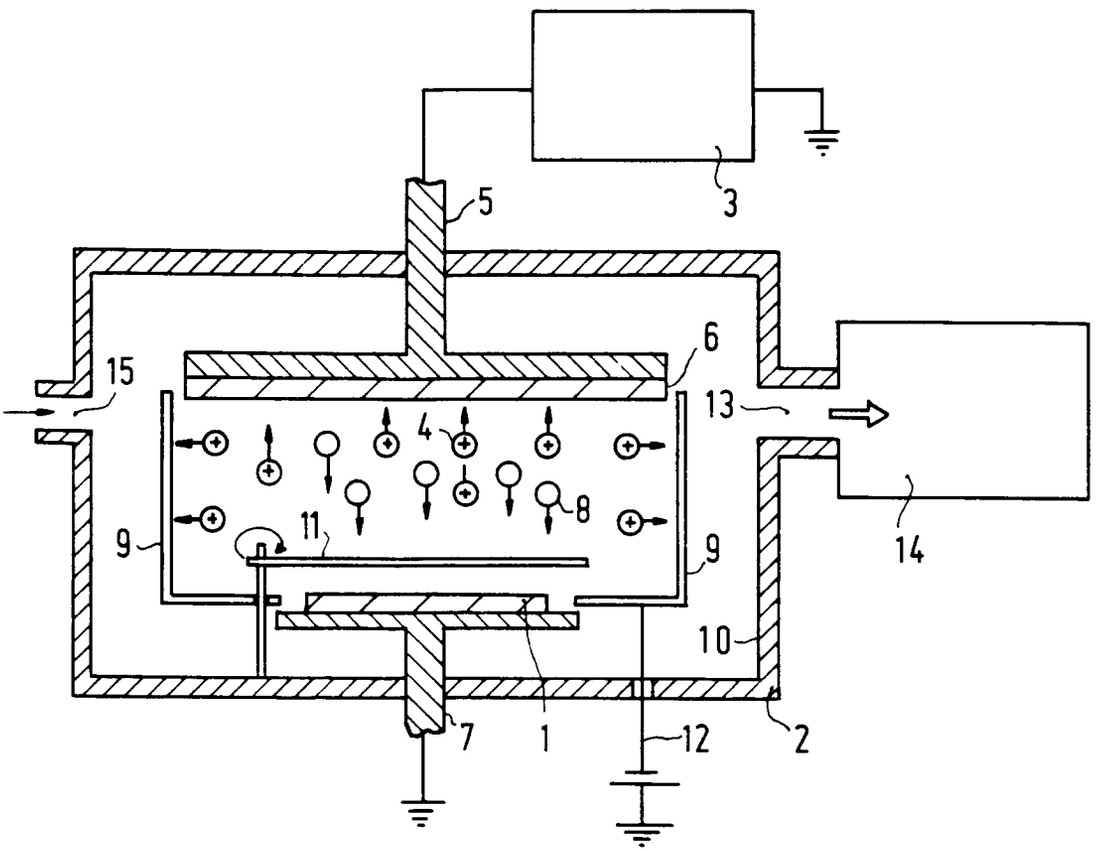
Revendications

1. Procédé pour réduire la contamination par particules pendant la pulvérisation dans un processus pour appliquer une couche sur un substrat, selon lequel, pendant un temps de processus déterminé, du matériau est détaché d'une plaque de cible par un bombardement de cette plaque de cible avec des ions à partir d'une décharge de gaz sous une pression réduite dans une chambre de réaction qui est munie d'un support pour le substrat, alors que des dispositions sont prises pour obtenir une meilleure adhérence du matériau déposé sur une surface d'un composant de chambre près du support, caractérisé a ce que la disposition pour donner une meilleure adhérence au matériau consiste dans un bombardement de la surface du composant de chambre avec des ions à partir de la décharge de gaz pendant au moins une partie du temps de processus.

2. Procédé selon la revendication 1, caractérisé en ce que le bombardement d'ions de la surface du composant de chambre s'effectue par application à cette surface d'un potentiel tel que les ions sont attirés de la décharge de gaz.

3. Procédé selon l'une des revendications précédentes, caractérisé en ce que le matériau est constitué par du tungstène ou un alliage de tungstène.

4. Procédé selon l'une des revendications précédentes, caractérisé en ce qu'un substrat présent dans le support est blindé pendant le bombardement du composant de chambre.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